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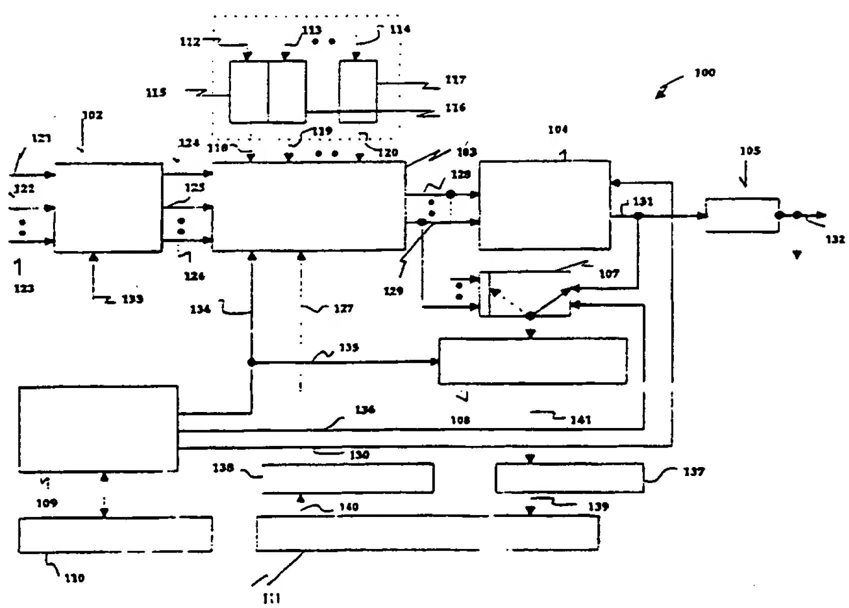

(57) Abstract

A sound placement system (100) and process produces from a plurality of input audio signals (118-120, 124-126, 127) at least two different output audio signals (131) which, when reproduced through respective speakers, give to a listener the illusion of distinct sound sources distributed into a three-dimensional space surrounding that listener. A multiplexer controller (103) combines the input audio signals (118-120, 124-126, 127) into at least one combined signal (128), and a demultiplexer controller (601) divides this combined signal (128) into multiple channel audio signals (604, 605, 606). Finally, a sound imaging unit (104) processes the multiple channel audio signals (604, 605, 606) to produce the two different output audio signals (131). A digital storage unit (111) is provided to store either the combined signal (128) or the output audio signals (131), and to supply them back to the multiplexer controller (103) for further combining and processing thereof.

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INTERACTIVE SOUND PLACEMENT SYSTEM AND PROCESS

BACKGROUND OF THE INVENTION

1. Field of the invention:

The present invention is concerned with the technology of sound placement creating an illusion of distinct sound sources distributed throughout the three-dimensional (3-D) space in which the listener(s) are located. More specifically, the present invention relates to a real-time interactive sound placement system and process which creates the illusion of distinct sound sources distributed throughout the 3-D space, by processing inputs audio signals. The processed input signals can be amplified and/or reproduced by conventional two-speaker stereo equipments to create virtual images of the sound sources in predetermined location.

2. Brief description of the prior art:

Numerous systems have been proposed in the prior art to create the impression to listeners that the reproduced audio sounds are emanating from different locations within the listeners space. Recently has been developed an audio digital signal processor system having the capabilities of controlling sound field in order to simulate for example concert halls, opera, etc. in a listening room

or in an automobile. Also, the digital signal processor is used to record or play back a digitized audio sound and/or MIDI data.

A process to produce an illusion of distinct sound sources distributed throughout a 3-D space using the conventional playback equipment has been developed and is described in United States patent N° 5,046,097 (Lowe et al.) issued on September 3rd, 1991. Equally based on this process have been developed two commercialized sound imaging systems for video game applications (United States patent N° 5,138,660 granted to Lowe et al. on August 11, 1992), and studio applications (United States patent N° 5,105,462 granted to Lowe et al. on April 14, 1992).

Typically, the prior art process places an image of a monaural sound source in a predetermined location. A plurality of such processed signals corresponding to different sources and positions may be mixed using conventional stereo equipment.

The sound processing involves dividing each monaural signal into two signals, and adjusting the differential phase and amplitude of the two-channel signals on a frequency dependent basis between these two signals. The resulting stereo signals may be reproduced using conventional playback techniques.

A variant of this prior art process is to create the phantom sound imaging, so that this phantom sound image will be apparent at several off-axis locations ranged in front of two loudspeakers (United

States patent N° 5,095,507 granted to Lowe on March 10, 1992). This phantom sound image has been obtained for multiple listeners ranged across the front of two speakers at several locations.

A drawback of these prior realisations is that the production and recording of sound placement information require sophisticated equipments.

OBJECTS OF THE INVENTION

The main object of the present invention is to provide an interactive sound placement system and process that combine multiple input monaural audio signals and that subsequently divide the combined signal into multiple monaural channel audio signals for sound image processing thereof. The combined signal facilitates storing, recombining, reprocessing, etc. of the multiple signals included therein.

SUMMARY OF THE INVENTION

More specifically, in accordance with the present invention, there is provided a combining and dividing circuit to be interposed between (a) a plurality of input audio signals and (b) sound image processing means for processing multiple channel audio signals to produce at least two different output audio signals which, when reproduced through respective

speakers, give to a listener the illusion of distinct sound sources distributed into a three-dimensional space surrounding said listener. This circuit comprises means for combining the input audio signals into at least one combined signal, and means for dividing the combined signal into the multiple channel audio signals supplied to the sound image processing means in order to produce at least the two output audio signals.

Also in accordance with the present invention, there is provided a sound placement system for producing from a plurality of input audio signals, at least two different output audio signals which, when reproduced through respective speakers, give to a listener the illusion of distinct sound sources distributed into a three-dimensional space surrounding the listener. This sound placement system comprises (a) means for combining the input audio signals into at least one combined signal, (b) means for dividing the combined signal into multiple channel audio signals, and (c) sound image processing means for processing the multiple channel audio signals to produce the two different output audio signals.

According to preferred embodiments of the invention:

- storage means are provided for storing the combined signal;

- the combining means includes means for producing multiple combined signals, and means are

provided for further combining the multiple combined signals into a smaller number of combined signals before storage thereof in the storage means;

- the storage means comprises means for supplying the combined signal to the combining means for further combining it with the input audio signals;

- also provided are means for compressing the at least one combined signal before storage thereof in the storage means, and means for decompressing the at least one combined signal supplied from the storage means to the combining means;

- the storage means stores the combined signal and the two different output audio signals, and switch means are controllable for supplying the combined signal or the two output audio signals to the storage means for storage thereof;

- the combining means comprises multiplexing means, and the dividing means comprises demultiplexing means;

- the dividing means comprises means for sequentially processing the combined signal to produce the at least two output audio signals; and

- the sound image processing means comprises means for placing the sound sources in the three-dimensional space surrounding the listener, and

means for remotely controlling these sound source placing means.

Further in accordance with the present invention, there is provided a sound placement process for producing from a plurality of input audio signals, at least two different output audio signals which, when reproduced through respective speakers, give to a listener the illusion of distinct sound sources distributed into a three-dimensional space surrounding said listener. This process comprises the steps of:

combining the input audio signals into at least one combined signal;

dividing the combined signal into multiple channel audio signals; and

processing the multiple channel audio signals to produce the two different output audio signals which, when reproduced through the respective speakers, give to the listener the illusion of distinct sound sources distributed into the above mentioned three-dimensional space.

The objects, advantages and other features of the present invention will become more apparent upon reading of the following non restrictive description of a preferred embodiment thereof, given by way of example only with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the appended drawings:

Figure 1 is a schematic block diagram of a preferred embodiment of the interactive sound placement system according to the present invention;

Figure 2 is a schematic block diagram of a slightly modified version of the interactive sound placement system of Figure 1;

Figure 3 is a schematic block diagram of a computer based interactive sound placement system according to the present invention;

Figure 4 is a schematic block diagram of a system controller of the computer based interactive sound placement system of Figure 3;

Figure 5 is a schematic block diagram of a multiplexer controller and a synthesizer of the computer based interactive sound placement system of Figure 3;

Figure 6 is a schematic block diagram of a sound imaging unit of the interactive sound placement system of Figure 1;

Figure 7 is a computer-graphic display used in controlling the computer based interactive sound placement system of Figure 3; and

Figure 8 is a front view of a remote control of the computer based interactive sound placement system of Figure 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 of the appended drawings illustrates an interactive sound placement system in accordance with the present invention. This apparatus is generally identified by the reference 100.

The interactive sound placement system 100 comprises a multiplexer controller 103 supplied with digital audio signal data from three sources.

A first source comprises multiple monaural analog audio signals such as 112, 113 and 114 converted to corresponding digital audio signal data by means of analog-to-digital converters such as 115, 116 and 117. These digital audio signal data are supplied to inputs such as 118, 119 and 120 of the multiplexer controller 103.

Another source is a digital input interface 102 fed by a plurality of monophonic/mixed or multiplexed digital audio signals such as 121, 122 and 123 from for example digital audio tapes (not shown) or compact-disk players (not shown). In response to the signals 121, 122 and 123, the digital input interface 102 supplies corresponding digital

audio signal data to inputs 124, 125 and 126 of the multiplexer controller 103.

A third source is a digital storage unit 111 supplying digital audio signal data to an input 127 of the multiplexer controller 103. When the digital audio signal data have been compressed before storage thereof, they are supplied from the storage unit 111 to the input 127 of the multiplexer controller 103 through a decompression unit 138. As will be seen in the following description, the audio signal data from the digital storage unit 111 are channel multiplexed audio signal data previously processed by the interactive sound placement system 100 or other compatible system and being stored in the unit 111.

The multiplexer controller 103 is designed to combine audio signal data from any of the inputs 118-120, 124-126 and 127 into at least one, for example time-division multiplex data stream such as 128 and 129. The data streams such as 128 and 129 are supplied to a sound imaging unit 104 for sound image processing as will be discussed in the following description. The number of concurrent multiplex data streams such as 128 and 129 depends on the data rate limitations of serial or parallel ports connection between the multiplexer controller 103 and the sound imaging unit 104, and on the number of ports available for the audio signal data transfer.

The data streams such as 128 and 129 may also be directed to the digital storage unit 111

through a compression unit 137, constituted for example by a hard disk, when a switch 107 is in the position shown in dashed line in Figure 1. The function of the unit 137 is to compress the data streams before storage in the digital unit 111. When the number of data streams such as 128 and 129 is higher than the number of tracks of the digital storage unit 111, these data streams 128 and 129 are further combined by means of another multiplexer controller 108 prior to being supplied to the digital storage unit 111. The data streams stored in the storage unit 111 can be supplied to the input 127 of the multiplexer controller 103. As can be appreciated, the number of multiplex data streams such as 128 and 129 is not restricted in the present invention.

Figure 2 illustrates an interactive sound placement system 200 identical to that 100 of Figure 1 but producing only one data stream 228 delivered from the multiplexer controller 203. The multiplexer controller 108 (Figure 1) is then omitted as shown in Figure 2.

Referring back to Figure 1, the function of the sound imaging unit 104 is to process the multiplex data streams such as 128 and 129 from the multiplexer controller 103 in relation to sound location information received from a system controller 109 through a line 130. As illustrated in Figure 6, the sound imaging unit 104 includes a demultiplexer controller 601 to divide the multiplex data streams such as 128 and 129 from the multiplexer controller

103 into a plurality of monaural channel signal data such as 604, 605 and 606. The monaural channel signal data 604, 605 and 606 may correspond or not to, or be combinations of the digital audio signal data 118-120, 124-126 and 127. Each monaural channel signal data is supplied to an individual sound imaging processor such as 607, 608 and 609. The sound imaging processors 607, 608 and 609 produce respective two-channel sound data such as 610, 611 and 612 having differential amplitude and phase relationship, which is based upon transfer functions contained within these digital imaging processors. Generally, for each location of a sound, a different transfer function is required. Sound location information for each monaural channel signal data 604, 605 and 606 is supplied to the sound imaging processors 607, 609 and 610 by the system controller 109 through line 130 (Figure 1). The processed two-channel sound data 610, 611 and 612 are applied to the inputs of a mixer controller 603. This mixer controller 603 sums all the two-channel sound data such as 610, 611 and 612 from the sound imaging processors 607, 608 and 609 to provide a digital two-channel audio output 131 (Figures 1 and 6). The digital two-channel audio output 131 is converted to an analog stereo signal 132 through an audio digital-to-analog converter 105, to enable playing thereof by conventional stereo audio systems (not shown).

The digital two-channel audio output 131 can be supplied to the digital storage system 111 through the compression unit 137 when the switch 107 is in the full-line position of Figure 1. The stored output can then be supplied through the decompression

unit to the input 127 of the multiplexer controller 103 to be played back. However, it cannot be reprocessed in the sound imaging unit 104.

In practice, the system controller 109 is a microcontroller, or any microprocessor device capable of controlling and synchronizing the interactive sound placement system 100 according to parameters previously stored or entered by the operator via a user control 110. More specifically, the system controller will control the digital input interface 102 through a line 133, the multiplexer controller 103 through a line 134, the multiplexer controller 108 through a line 135, the switch 107 through a line 136, and, as indicated earlier, the sound imaging unit 104 through the line 130. The user control 110 enables the operator to control the process performed by the interactive sound placement system 100, including the placement of the sound sources, and may comprise graphic/characters display means, microprocessor means, and a keyboard or mouse.

For interactively placing a sound, the operator, by means of the graphic display and the keyboard or mouse of the user control 110, indicates the location of the sound for each channel signal data such as 604, 605 and 606. The sound's location information is translated into commands and instructions and directed to the system controller 109. The system controller 109 then passes the sound location information to the sound imaging processors 607, 608 and 609 through the line 130. This technology, used to place a sound at a given location,

is known to those skilled in the art and will not be further described in the present specification.

The audio channels (see 604, 605 and 606) can be deactivated or activated through the user control 110. The corresponding instructions are transferred from the user control 110 to the system controller 109 which then activates or deactivates the specific channel by instructing the corresponding sound imaging processor 607, 608 or 609 to process or not that channel.

Control of the position of switch 107 is also carried out through commands entered by the operator via the user control 110. These commands are supplied from the user control 110 to the system controller 109 to change the position of switch 107 through the line 130. When the switch 107 is in the position shown in dashed lines in Figure 1, the multiplex data streams from the multiplexer controller 103 are applied to the input of the digital storage unit 111. As mentioned in the foregoing description, the multiplex data streams stored in the unit 111 can be applied to the input 122 of the multiplexer controller 103 to be played back and eventually further multiplexed in the controller 103 and further processed in the sound imaging unit 104, as desired. The number of channel signal data (see 604, 605 and 606) being multiplexed for recording is determined at the beginning of the process by the operator.

Referring now to Figure 3, a computer based interactive sound placement system 300 in

accordance with the present invention is illustrated under the form of block diagram. The interactive sound placement system 300 comprises a computer 304 forming both the user control (110 in Figure 1) and the digital storage unit (111 in Figure 1). The computer 304 is associated to a display 301, a keyboard 303 and/or mouse 302. A microcontroller 305 constitutes the system controller (109 in Figure 1). A digital signal processor (DSP) 310 is used as digital input interface (102 in Figure 1) and multiplexer controller (103 in Figure 1); and a digital signal processor (DSP) 312 forms the sound imaging unit (104 in Figure 1). The digital signal processor 310 communicates with the microcontroller 305 through a buffer 307, while the digital signal processor 312 communicates with the microcontroller 305 through another buffer 308. A third buffer 311 interconnects the digital signal processors 310 and 312.

The architecture of the microcontroller 305 is illustrated in Figure 4.

The heart of this microcontroller is a central processing unit (CPU) 401 connected to the computer 304 (Figure 3) through a user control interface 402 and through a digital storage interface 403. Accordingly, the commands, instructions and sound location information can be passed from the computer 304 to the rest of the system by means of the central processing unit 401. The digital storage interface 403 typically is a direct memory access (DMA) controller for fast data transfer between the

system and the computer storage unit such as a hard disk. The user control interface consists of a group of input/output ports accessed by computer to communicate with the central processing unit 401 of the system controller.

The central processing unit 401 accesses a program and data memory 407 through a memory interface 406 to retain the user's operation program and temporary calculation results.

The microcontroller 305 may for example comprise a MIDI interface 404, constituting the digital input interface 102 of Figure 1, to enable the central processing unit 401 to communicate with a MIDI instrument 306 (Figure 3). The MIDI data received are buffered into a shared RAM 409, constituting the buffer 307 of Figure 3, through the MIDI interface 404, the central processing unit 401, and a DSP interface 408. These data are retrieved by the digital signal processor 310 for audio synthesis.

The channel multiplexed audio signal data (127 in Figure 1) from the computer 304 are also transferred to the digital signal processor 310 through the digital storage interface 403, the central processing unit 401, the DSP interface 408 and the shared RAM 409. The shared RAM 409 is also used for retransmitting multiplex data streams (128, 129 in Figure 1) from the digital signal processor 310 (multiplexer controller) back to the computer 304 for storage thereof. The shared RAM 409 has two registers dedicated to communication between processors.

The shared RAM 410 has the same configuration as shared RAM 409 and is used for transmitting the processed digital two-channel audio output (131 in Figure 1) from the digital signal processor 312 (sound imaging unit) back to computer 304 for storage therein.

As can be appreciated, the two shared RAMs 409 and 410 replace the two inputs 128-129 and 131 of the switch 107 of Figure 1.

A remote control interface 405 provides the necessary circuits to support a remote control receiver (not shown) itself receiving information from a remote control 314 (Figure 3).

The DSP interface 408 provides circuitry necessary to support the shared RAMs 409 and 410 for data, commands and status interchange between the microcontroller 305 and the digital signal processors 310 and 311. Practically, the DSP interface 408 is a portion of memory space accessible by the microcontroller 305 and reserved for communication with the digital signal processors 310 and 312.

Referring to Figure 5, operation of the digital signal processor 310 will be described. As indicated in the foregoing description, the digital signal processor 310 has the function of multiplexer controller and audio synthesizer. A plurality of monaural analog audio signals 513-516 are supplied to the digital signal processor 310 by means of an audio interface 504 through a series of analog-to-digital

converters 505. The digital signal processor 310 includes an address and data bus 517 to which the shared RAM 409 is connected to enable bidirectional communication between the processor 310 and the microcontroller 305. Also connected on the address and data bus is a program and data memory 501 storing the program of the processor 310 and temporary data. A wavetable memory 502, connected on the bus 517, stores sample sound for sound synthesis.

A buffer memory 506, typically a FIFO or dual port RAM, is used to transfer multiplex data streams (128-129 in Figure 1) to the digital signal processor 312 carrying out the function of sound imaging processing. A synchronous serial communication line 507 is also available for bidirectional communication between the digital signal processors 310 and 312.

The digital signal processor 310 is programmed to synthesize the MIDI data transferred thereto from the microcontroller 305 through the shared RAM 409. The synthesized data are multiplexed with the audio signal data 513-516 received from the audio interface 504 and eventually audio data stored in shared RAM 409. The obtained multiplex data streams (128-129 in Figure 1) are sequentially transferred to the digital signal processor 312 through the buffer memory 506. These data streams also may be redirected to the computer 304 for digital storage through the shared RAM 409 and microcontroller 305.

The digital signal processor 312, carrying out the function of sound imaging unit (104 in Figure 1), receives and processes sequentially multiplexed audio signal data from the buffer memory 506 by applying the appropriate transfer functions according to the sound placement information issued from the system controller 109 (microcontroller 305) via the shared RAM 509. The two-channel sound data (610, 611 and 612 in Figure 6) from each channel are then summed into the digital two-channel audio output 131 and supplied to the stereo digital-to-analog converter 105 to produce the analog stereo signal 132 capable of being played back by conventional stereo systems (not shown). The digital two-channel audio output 131 may also be redirected to the digital storage computer 304 through the microcontroller 305 and the shared RAM 509.

In operation, by the way of keyboard 303, the user enter the audio file to be played, activates the MIDI interface 404 in specifying the number of MIDI channels the MIDI instrument 306 may produce, activates the analog audio inputs (see signals 213-214 in Figure 1) desired. The computer accesses the desired audio file, reads the header information to determine the number of channels being multiplexed, the sample data rates, and the quantization bit. The audio data will then be transferred to the system controller 109 through the digital storage interface 403 to be stored in the shared RAM 409, and the commands will issue to the system controller 109 through I/O ports of the user control interface 402. The header information contained in the audio file is

also displayed on graphics means of the display 301. The sampling rate of the analog-to-digital converters and of the audio synthesis and the quantization bit are determined to match the audio file data format. The system controller 109 processes the commands received, informs the digital signal processor 310 of the number of channels and data format that will be played including the number of MIDI channels and the analog-to-digital converters that will be supported. The digital signal processor 310 also receives information required for controlling the analog-to-digital converters.

In Figure 7, an embodiment of the graphic display 701 (display 301 of Figure 3) is illustrated. The user assigns each active channel to a number and places these channels to a specific location such as 705 related to the position of the two speakers 706 and 707 by means of graphic display 701 and the keyboard 303 (Figure 3), the mouse 302 (Figure 3) or a position control 702 shown in Figure 7. The computer 304 processes the user's commands and transfers these commands to the system controller 109 (Figure 1). The channel assignment will be transferred to the digital signal processor 310 for channels multiplexing, and the sound location information will be transferred to the digital signal processor 312 for sound placement processing.

The operator has the choice between recording the multiplex data streams (128-129 in Figure 1) or the 3-D (three-dimensional) processed digital two-channel audio output (131 in Figure 1) by

entering the submenu represented by record 704. In response to this command, the system controller 109 informs either the digital signal processor 310 to return to the computer 304 the multiplex data streams or the digital signal processor 312 to return to the computer 304 the 3-D processed digital two-channel audio output through the shared RAMs 409 and 410, respectively. The multiplex data streams stored on the hard disk of the computer 304 can be supplied back to input 127 of the multiplexer controller 103 and played back under the control of the listener regarding the sound location. The 3-D processed digital two-channel audio output stored in the computer 304 can only be played back as normal stereo audio file without any control of the listener on the sound location.

Figure 8 depicts an embodiment of the remote control 314 of Figure 3, by which the interactive sound placement system is partially controlled. The remote control 314 comprises: a channel selecting section 801 for selecting channels (604,605,606 in Figure 6) to be modified; a channel active section 803 to selectively activate or deactivate channels; a sound position section 808 for positioning the sound location of a given channel; a volume adjusting section 810 for regulating the sound in various manners. In operation, the operator can deactivate or reactivate selected channels already selected by the computer setup by sequentially depressing a channel select key 802, keys 801 corresponding to the number of that channel, and one channel on/off key 803, the process being terminated by depressing the ENTER key 809.

For adjusting the sound location of a given channel, the operator first selects the desired channel by sequentially depressing the channel select key 802, the keys 801 corresponding to the number of the channel, the "up" key 805, "down" key 807, "left" key 804, and/or "right" key 806 to move the sound location forwardly, backwardly, toward the left, or toward the right, respectively from its actual position. The sound location modification process is terminated when the user press the ENTER key 809.

When the channel select key 802 is depressed, the system controller 109 starts the modification program. The channel selected and the appropriate action are decoded. If the operator depresses one channel on/off key 803, the system controller 109 asks the digital signal processor 312 to process or not process the selected channel, and updates the graphic display means 301 by transferring the information back to the computer 304. If the channel selected is not in the set of channels selected during starting of the process, the erroneous information is sent back to computer 304 for display thereof and the system controller 109 takes no action. If one of the four sound position keys 804-807 is depressed, the system controller 109 calculates the new channel sound location according to the channel sound location information previously stored in the memory 407 of the system controller. The step change is defined by the user program and by the performance of the sound imaging digital signal processor 312. The new sound location information is then transferred to the digital signal processor 312 for modifying the

channel transfer function, and to the computer 304 for updating the graphic display means 301.

Although the present invention has been described hereinabove by way of a preferred embodiment thereof, this embodiment can be modified at will, within the scope of the appended claims, without departing from the spirit and nature of the subject invention.

CLAIMS

1. A combining and dividing circuit to be interposed between (a) a plurality of input audio signals and (b) sound image processing means for processing multiple channel audio signals to produce at least two different output audio signals which, when reproduced through respective speakers, give to a listener the illusion of distinct sound sources distributed into a three-dimensional space surrounding said listener, said circuit comprising:

means for combining said plurality of input audio signals into at least one combined signal; and

means for dividing said combined signal into said multiple channel audio signals supplied to said sound image processing means in order to produce said at least two output audio signals.

2. A combining and dividing circuit as recited in claim 1, further comprising storage means for storing said at least one combined signal.

3. A combining and dividing circuit as recited in claim 2, further comprising means for compressing said at least one combined signal before storage thereof in said storage means.

4. A combining and dividing circuit as recited in claim 2, wherein said combining means includes means for producing multiple combined signals, and wherein said circuit comprises means for

further combining said multiple combined signals into a smaller number of combined signals before storage thereof in said storage means.

5. A combining and dividing circuit as recited in claim 2, wherein said storage means comprises means for supplying said at least one combined signal to said combining means for further combining it with said input audio signals.

6. A combining and dividing circuit as recited in claim 5, further comprising means for decompressing said at least one combined signal supplied from said storage means to said combining means.

7. A combining and dividing circuit as recited in claim 3, wherein said storage means comprises means for supplying said at least one compressed combined signal to said combining means through means for decompressing said at least one compressed signal, whereby said at least one decompressed signal can be further combined with said input audio signals.

8. A combining and dividing circuit as recited in claim 1, comprising storage means for storing said at least one combined signal and for storing said at least two different output audio signals, and switch means controllable for supplying said at least one combined signal or said at least two output audio signals to the storage means for storage thereof in said storage means.

9. A combining and dividing circuit as recited in claim 1, wherein said combining means comprises multiplexing means, and wherein said dividing means comprises demultiplexing means.

10. A combining and dividing circuit as recited in claim 1, wherein said dividing means comprises means for sequentially processing said combined signal to produce said at least two output audio signals.

11. A sound placement system for producing from a plurality of input audio signals, at least two different output audio signals which, when reproduced through respective speakers, give to a listener the illusion of distinct sound sources distributed into a three-dimensional space surrounding said listener, said sound placement system comprising:

means for combining said plurality of input audio signals into at least one combined signal;

means for dividing said combined signal into multiple channel audio signals; and

sound image processing means for processing said multiple channel audio signals to produce said at least two different output audio signals which, when reproduced through said speakers, give to said listener the illusion of distinct sound sources distributed into said three-dimensional space.

12. A sound placement system as defined in claim 11, further comprising storage means for storing said at least one combined signal.

13. A sound placement system as defined in claim 12, further comprising means for compressing said at least one combined signal before storage thereof in said storage means.

14. A sound placement system as defined in claim 12, wherein said combining means includes means for producing multiple combined signals, and wherein said sound placement system comprises means for further combining said multiple combined signals into a smaller number of combined signals before storage thereof in said storage means.

15. A sound placement system as defined in claim 12, wherein said storage means comprises means for supplying said at least one combined signal to said combining means for further combining it with said input audio signals.

16. A sound placement system as defined in claim 15, further comprising means for decompressing said at least one combined signal supplied from said storage means to said combining means.

17. A sound placement system as defined in claim 13, wherein said storage means comprises means for supplying said at least one compressed combined signal to said combining means through means for decompressing said at least one compressed signal, whereby said at least one decompressed signal can be further combined with said input audio signals.

18. A sound placement system as defined in claim 11, comprising storage means for storing said at least one combined signal and for storing said at least two different output audio signals, and switch means controllable for supplying said at least one combined signal or said at least two output audio signals to the storage means for storage thereof in said storage means.

19. A sound placement system as defined in claim 11, wherein said combining means comprises multiplexing means, and wherein said dividing means comprises demultiplexing means.

20. A sound placement system as defined in claim 11, wherein said dividing means comprises means for sequentially processing said combined signal to produce said at least two output audio signals.

21. A sound placement system as defined in claim 11, wherein said sound image processing means comprises means for placing said sound sources in said three-dimensional space, and means for remotely controlling said sound source placing means.

22. A sound placement process for producing from a plurality of input audio signals, at least two different output audio signals which, when reproduced through respective speakers, give to a listener the illusion of distinct sound sources distributed into a three-dimensional space surrounding said listener, said sound placement process comprising the steps of:

combining said plurality of input audio signals into at least one combined signal;

dividing said combined signal into multiple channel audio signals; and

processing said multiple channel audio signals to produce said at least two different output audio signals which, when reproduced through said speakers, give to the listener the illusion of distinct sound sources distributed into said three-dimensional space.

23. The sound placement process of claim 22, further comprising the step of storing said at least one combined signal.

24. The sound placement process of claim 23, further comprising the step of compressing said at least one combined signal before storage thereof.

25. The sound placement process of claim 23, wherein said combining step comprises the step of producing multiple combined signals, and wherein said process comprises the step of further combining said multiple combined signals into a smaller number of combined signals before storage thereof.

26. The sound placement process of claim 23, comprising the step of further combining said stored combined signal with said input audio signals.

27. The sound placement process of claim 26, further comprising the step of decompressing said

at least one stored combined signal before further combining it with said input audio signals.

28. The sound placement process of claim 24, comprising the steps of further combining said stored combined signal with said input audio signals, and of decompressing said at least one compressed combined signal before further combining it with said input audio signals

29. The sound placement process of claim 22, further comprising the step of selectively storing said at least one combined signal or said at least two output audio signals.

30. The sound placement process of claim 22, wherein said combining step comprises the step of multiplexing said input audio signals to form a multiplex signal, and wherein said dividing step comprises the step of demultiplexing said multiplex signal to produce said multiple channel audio signals.

31. The sound placement process of claim 22, wherein said dividing step comprises the step of sequentially processing said combined signal to produce said at least two output audio signals.

32. The sound placement process of claim 22, wherein said processing step comprises the step of placing said sound sources in said three-dimensional space, and the step of remotely controlling said sound source placing step.

FIG. 1

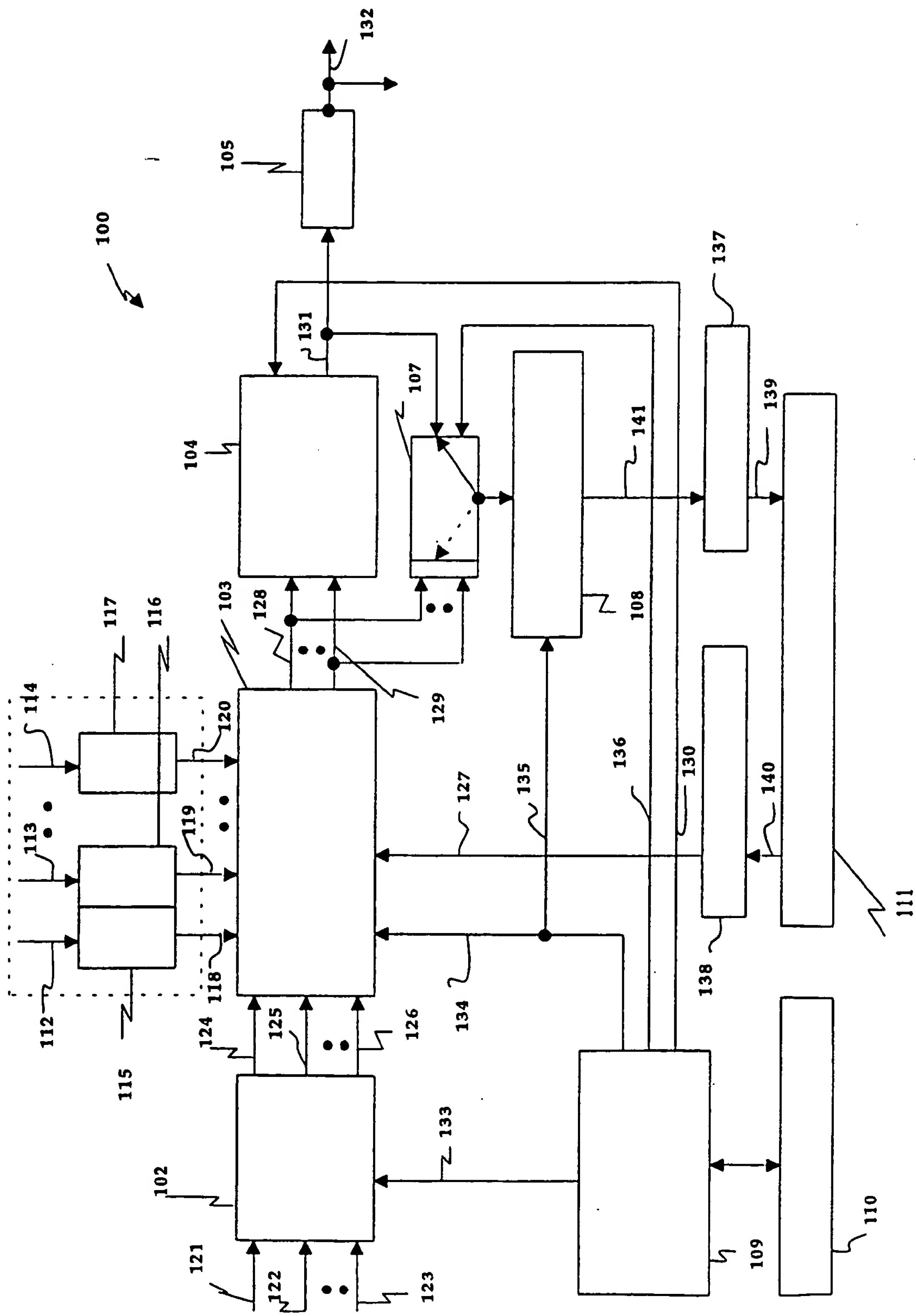
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FIG. 2

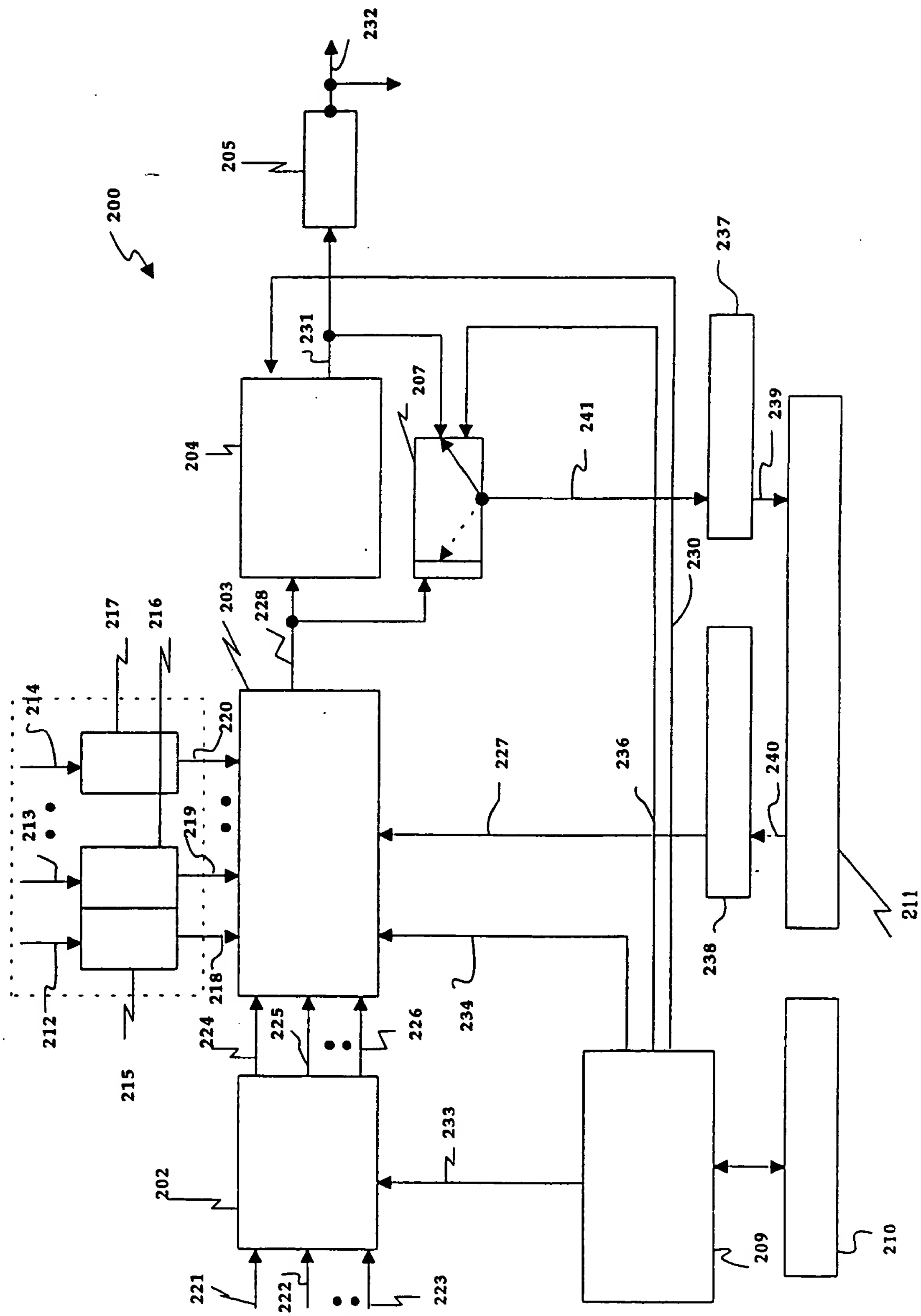
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FIG. 3

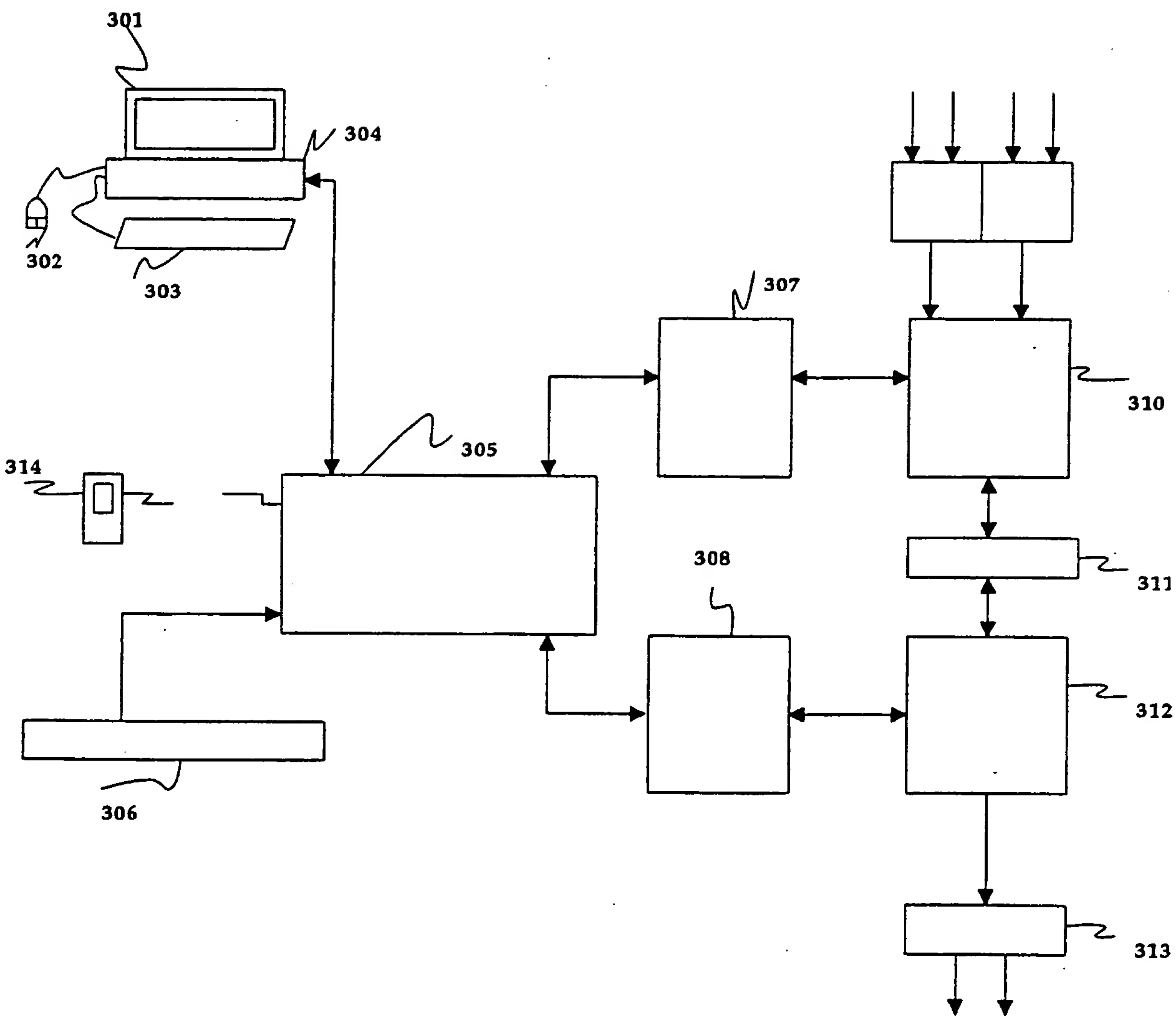

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FIG. 4

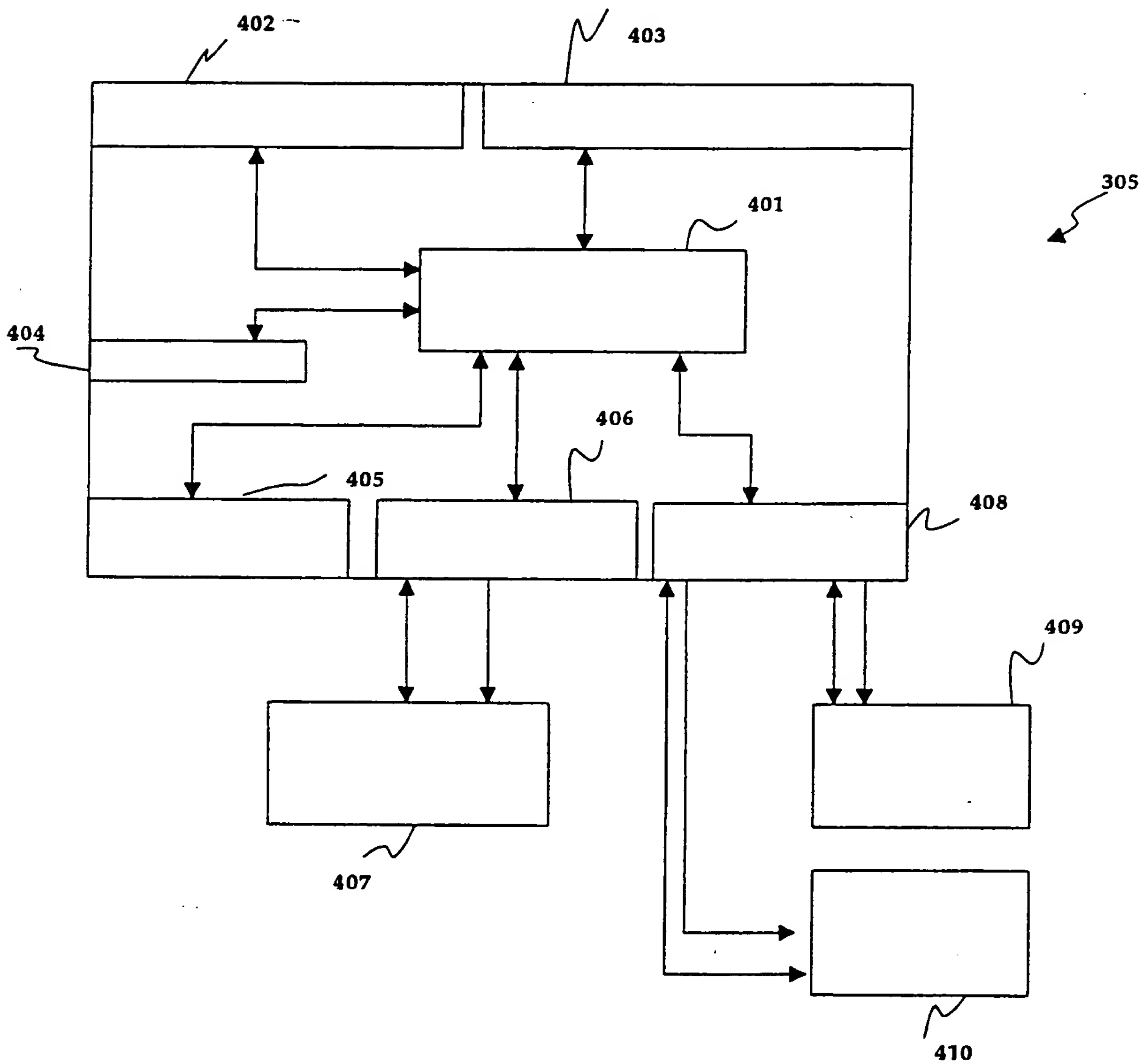

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FIG. 5

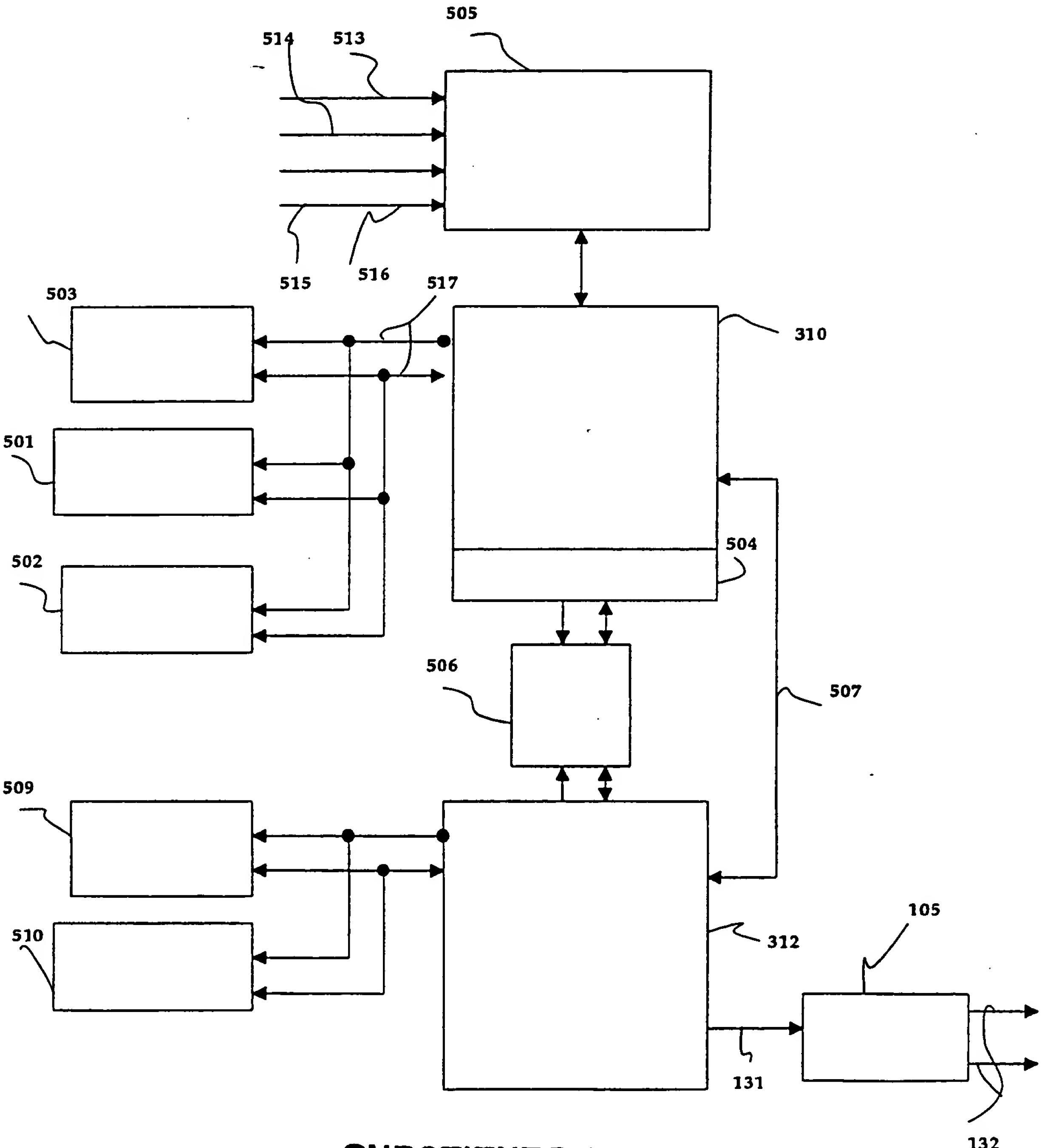

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FIG. 6

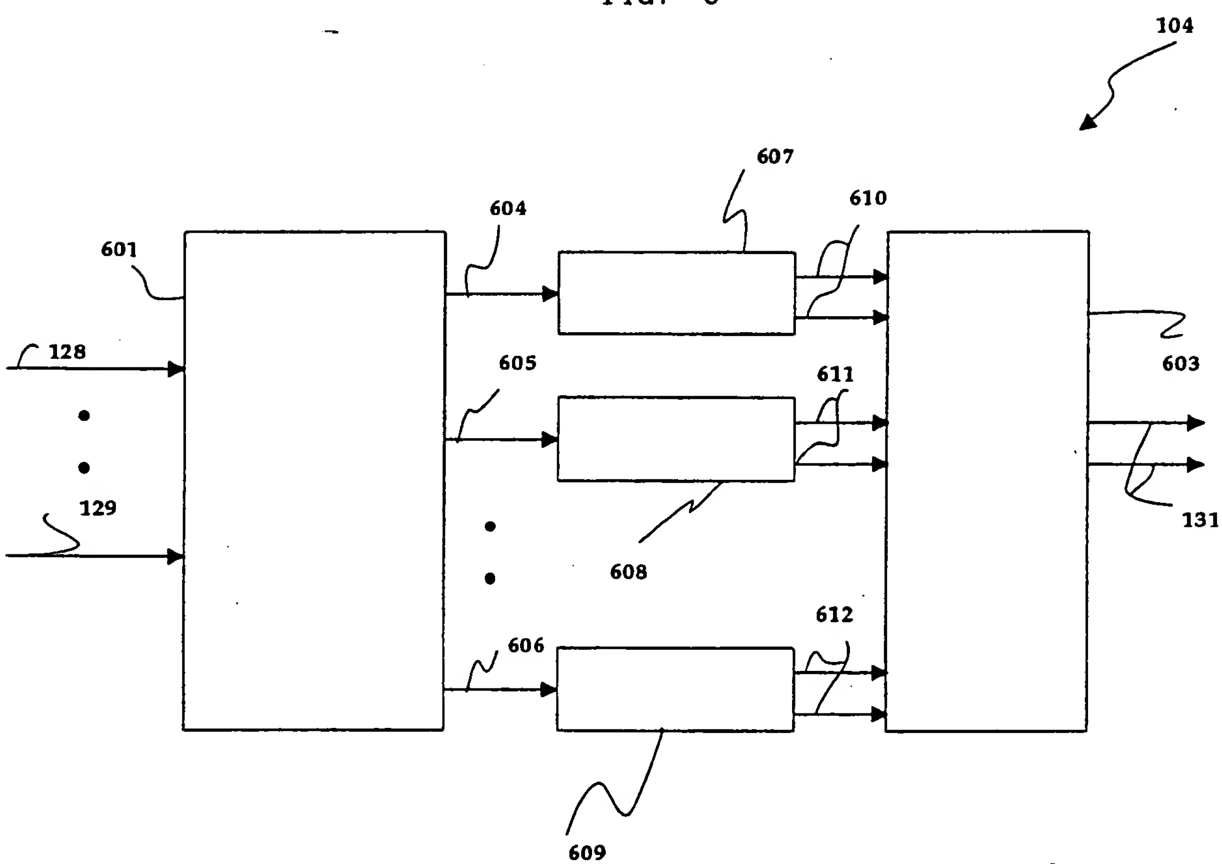
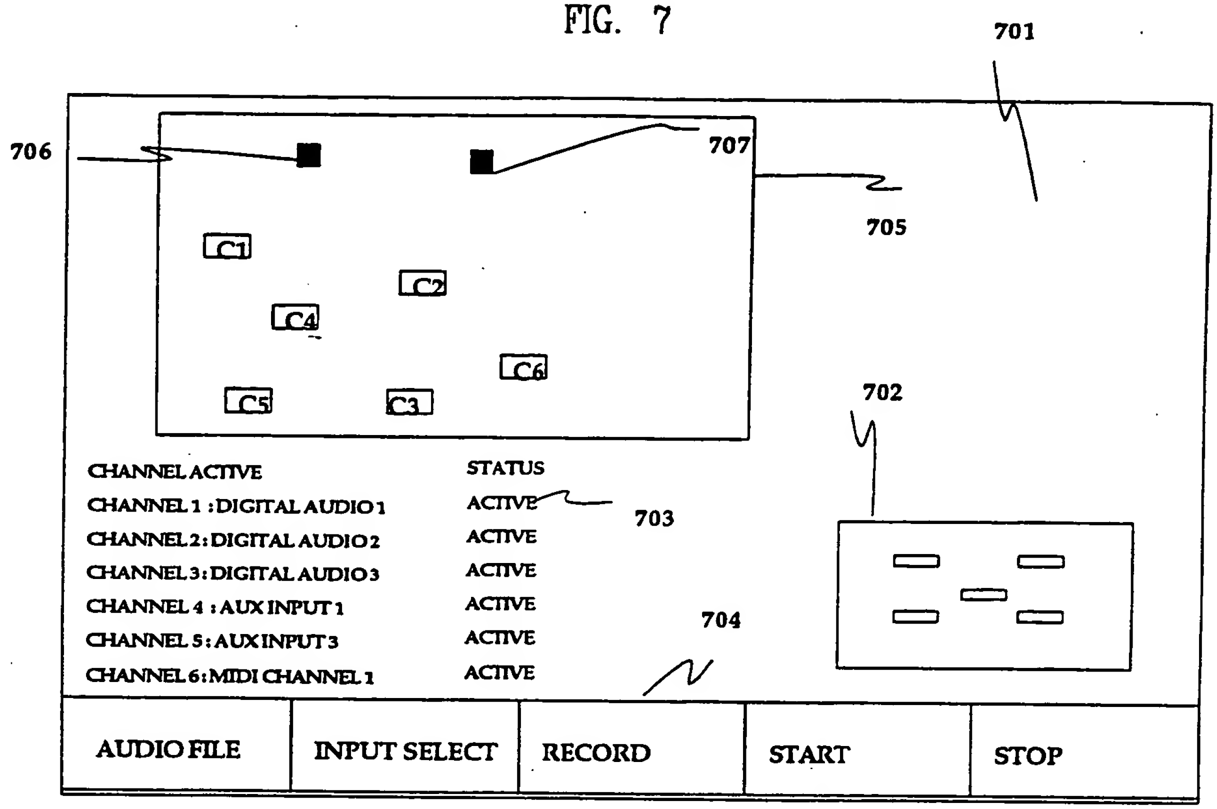


FIG. 7



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C1
C2
C4
C6
C5
C3
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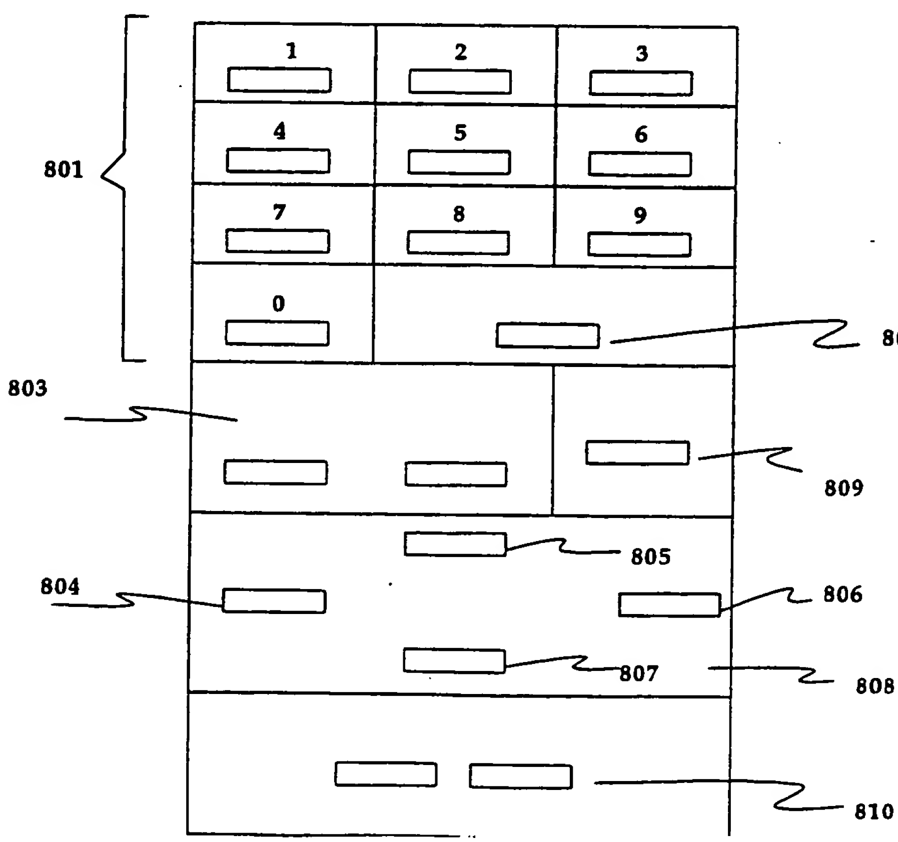
CHANNEL ACTIVE
STATUS
CHANNEL 1 :DIGITAL AUDIO 1
ACTIVE
703
CHANNEL 2: DIGITAL AUDIO 2
ACTIVE
CHANNEL 3: DIGITAL AUDIO 3
ACTIVE
CHANNEL 4 : AUX INPUT 1
ACTIVE
704
CHANNEL 5: AUX INPUT 3
ACTIVE
CHANNEL 6: MIDI CHANNEL 1
ACTIVE
AUDIO FILE
INPUT SELECT
RECORD
START
STOP

FIG. 8



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A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 H04S7/00 H04S5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 H04S H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR,A,2 592 735 (ESPACE MUSICAL ET AL.) 10 July 1987 see claims; figures ---	1,11,18, 22
A	EP,A,0 357 402 (Q SOUND LTD) 7 March 1990 see page 3, line 46 - page 5, line 7; figures	1,11,18, 22
A	& US,A,5 046 097 (LOWE ET AL.) cited in the application	1,11,18, 22
A	& US,A,5 105 462 (LOWE ET AL.) cited in the application ---	1,11,18, 22

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 December 1993	20.01.94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gastaldi, G

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	& US,A,5 138 660 (LOWE ET AL.) cited in the application ---	1,11,18, 22
A	US,A,5 095 507 (LOWE) 10 March 1992 cited in the application see column 4, line 25 - column 5, line 23; figures ---	1,11,18, 22
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